Nota Lepi. **38**(2) 2015: 161–169 | DOI 10.3897/nl.38.6312

Enantiomers of 2-butyl 7*Z*-dodecenoate are sex attractants for males of *Adscita mannii* (Lederer, 1853), *A. geryon* (Hübner, 1813), and *Jordanita notata* (Zeller, 1847) (Lepidoptera: Zygaenidae, Procridinae) in Italy

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http://zoobank.org/0D97E7B1-EA1D-4E2D-B6B2-5E6252577D43

Received 23 August 2015; accepted 30 October 2015; published: 10 November 2015
Subject Editor: Thomas Fartmann.

Abstract. The R- and S-enantiomers of 2-butyl (7*Z*)-dodecenoate (alone or in mixtures), recently identified in the natural extracts of *Illiberis rotundata* pheromone glands, were used as lures in sticky traps to study the occurrence of Procridinae species in Italy in 14 localities during 2010 and 2011. Three species were attracted during the study – *Adscita mannii* (Lederer, 1853), *A. geryon* (Hübner, 1813), and *Jordanita notata* (Zeller, 1847). The most numerous species was *A. mannii*. Lures with (2*S*)-butyl (7*Z*)-dodecenoate attracted males of *Adscita mannii* and *A. geryon*, while those containing (2*R*)-butyl (7*Z*)-dodecenoate attracted males of *Jordanita notata*.

Introduction

Four pheromone compounds were identified in extracts of female sex pheromone glands of *Illiberis* (*Primilliberis*) *rotundata* Jordan, 1907: (2*R*)-butyl (7*Z*)-dodecenoate [R-7-12], (2*S*)-butyl (7*Z*)-dodecenoate [S-7-12], (2*R*)-butyl (9*Z*)-tetradecenoate [R-9-14] and (2*S*)-butyl (9*Z*)-tetradecenoate [S-9-14] (Subchev et al. 2009). Mixtures of two of them, R-7-12 and R-9-14, were found to be attractive for the males of *I. rotundata* and *I.* (*P.*) *pruni* Dyar, 1905 (Subchev et al. 2012; 2013). Our experience with the use of all four components in Bulgaria, Crimea, Hungary, Armenia, Turkey, and Afghanistan (Efetov et al. 2008, 2010a, 2010b, 2011; Efetov et al. 2014; Subchev 2014; Subchev et al. 2010) showed that only R-7-12 and S-7-12 and their mixtures were attractive for different species of the genera *Rhagades* Wallengren, 1863, *Zygaenoprocris* Hampson, 1900, *Adscita* Retzius, 1783, and *Jordanita* Verity, 1946. Thus, during our field trips in Italy in 2010 and 2011 we used only the last two mentioned substances.

Zygaenidae fauna of Italy is represented by 45 species, of which 14 belong to the subfamily Procridinae (Bertaccini and Fiumi 1999; Efetov 1994, 2004; Efetov and Tarmann 1999, 2000, 2014; Efetov et al. 2011). The aim of our work was to check the attractiveness of R-7-12 and S-7-12 and their mixtures for Italian species of Procridinae.

Materials and methods

The pheromone compounds were synthesized at the Institute of Organic Chemistry, Hamburg University, and pheromone baits and traps were prepared at the Institute of Zoology, Bulgarian Academy of Sciences. For pheromone baits we used penicillin vial caps of grey rubber on which the synthetic pheromone compounds were applied as hexane solutions. After evaporation of the solvent, the caps were wrapped in aluminium foil and kept in a refrigerator at 5 °C until ready for use. In most cases, sticky Delta traps were used. The removable sticky layers were covered with Tanglefoot® insect glue. In addition to the sticky traps we also used commercially available traps (plastic cylinders) for obtaining living material. Moreover, in some localities we also collected attracted specimens by netting them.

Traps baited with the synthetic Procridinae sex pheromone compounds R-7-12 and S-7-12 alone and in mixtures were placed and inspected in the field in 14 habitats located from northern Italy (Alps) to the southern part of the country (Calabria) during the periods 9.vi–18.vi.2010 and 28.vi–8.vii.2011. During these two periods the first two authors travelled from the Alps to southern Italy and placed traps in position during the southwards trip and checked them on the return trip northwards (Efetov et al. 2012).

List of studied localities in Italy (Figs 1–3)

2010

Province L'Aquila, Rocca di Mezzo, 1322 m, traps placed 9.vi.2010, traps inspected 9.vi. and 17.vi.2010.
Province L'Aquila, Sperone, 1212 m, placed 9.vi.2010, inspected 9.vi., 17.vi. and 18.vi.2010.
Province Latina, Lenola, 534 m, placed 10.vi.2010, inspected 10.vi. and 16.vi.2010.
Province Napoli, Monte Faito, 843 m, placed 11.vi.2010, inspected 11.vi.2010.
Province Potenza, Roccarossa, 1370 m, placed 12.vi.2010, inspected 12.vi., 13.vi. and 15.vi.2010.
Province Potenza, Monte Pollino, 1206 m, placed 13.vi.2010, inspected 13.vi., 14.vi. and 15.vi.2010.
Province Cosenza, Lago Ampollino, 1308 m, placed 15.vi.2010, inspected 15.vi.2010.

2011

Province Verona, Monte, 316 m, placed 28.vi.2011, inspected 8.vii.2011.
Province Bologna, Loiano NNW, 248 m, placed 28.vi.2011, inspected 8.vii.2011.
Province Potenza, Roccarossa, 1370 m, placed 30.vi.2011, inspected 3.vii., 4.vii. and 5.vii.2011.
Province Cosenza, Lago Ampollino, 1308 m, placed 30.vi.2011, inspected 1.vii., 2.vii. and 3.vii.2011.
Province Potenza, Lagonegro NE, 1340 m, placed 4.vii.2011, inspected 4.vii. and 5.vii.2011.
Province Chieti, Castiglione Messer Marino N, 873 m, placed 5.vii.2011, inspected 6.vii.2011.
Province L'Aquila, Capistrello (1), 757 m, placed 6.vii.2011, inspected 7.vii.2011.
Province L'Aquila, Capistrello (2), 911 m, placed 6.vii.2011, inspected 7.vii.2011.
Province Roma, Cervara di Roma, 1127 m, locality visited on 7.vii.2011.
Province Roma, Jenne, 936 m, locality visited on 7.vii.2011.
Province Trento (Trentino), Monte Bondone, 967 m, trap placed 9.vii.2011, inspected 9.vii.2011.

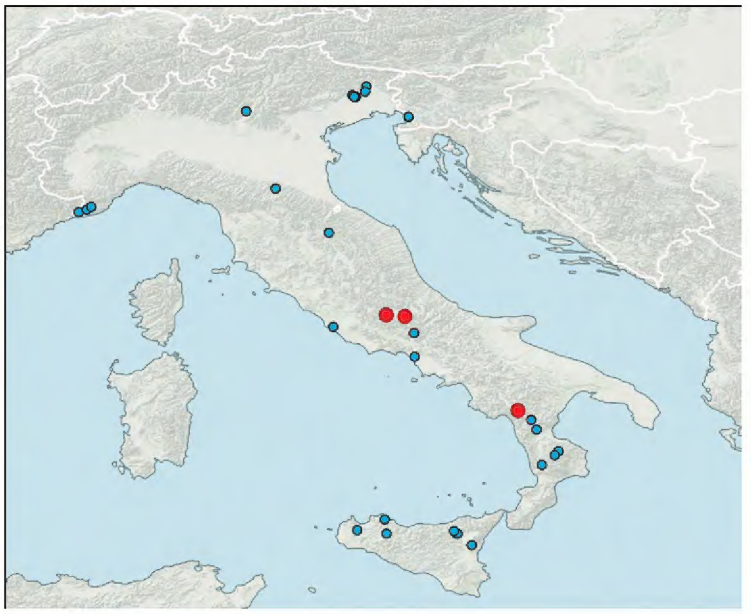

Figure 1. Distribution of *Jordanita notata* in Italy (blue dots) and studied localities with attracted specimens (red dots).

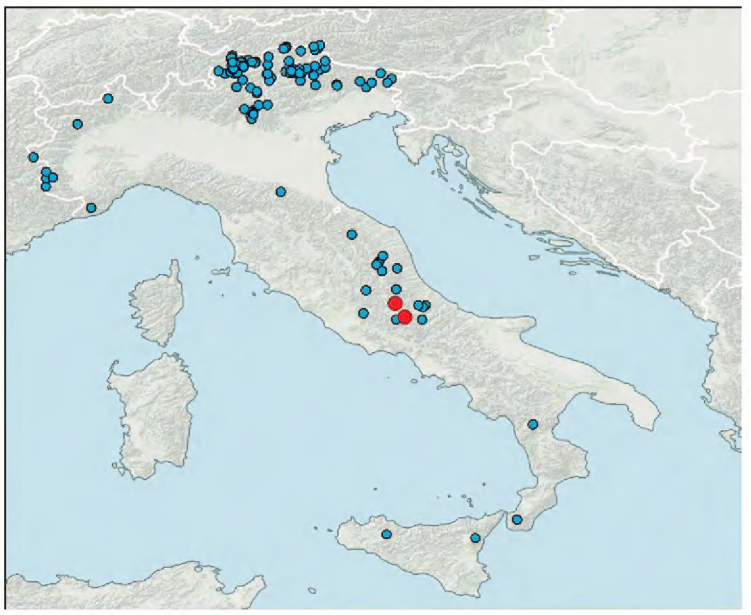

Figure 2. Distribution of *Adscita geryon* in Italy (blue dots) and studied localities with attracted specimens (red dots).

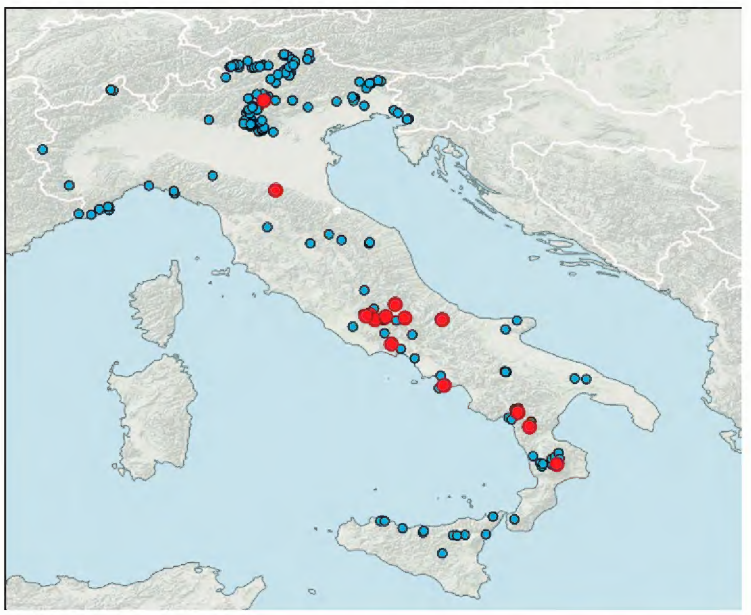

Figure 3. Distribution of *Adscita mannii* in Italy (blue dots) and studied localities with attracted specimens (red dots).

Results

Three Procridinae species were attracted to R-7-12 and S-7-12 and their mixtures (Figs 1–3), viz. *Adscita* (*Tarmannita*) *mannii* (Lederer, 1853), *A.* (*Adscita*) *geryon* (Hübner, 1813), and *Jordanita* (*Tremewania*) *notata* (Zeller, 1847). *Jordanita notata* males (9 specimens) were attracted to R-7-12 or mixtures containing this compound in two habitats in the province of L'Aquila and one habitat in the province of Potenza (Fig. 4, Table 1). *Adscita geryon* males (4 specimens) were attracted in two habitats in the province of L'Aquila (Table 2). *A. mannii* males (136 specimens) were attracted to S-7-12 or mixtures containing this compound in the provinces of Trentino, Bologna, L'Aquila, Roma, Latina, Chieti, Napoli, Potenza, and Cosenza (Fig. 5, Table 3). Twelve specimens of *A. mannii* in the habitats Sperone (2010), Cervara di Roma (2011), and Jenne (2011) were attracted to the box containing all substances immediately after opening the bag, which is why they were not included in Table 3.

When all three variants of the attractant were present in the habitat (S-7-12, R-7-12 and their mixture), *A. mannii* came mainly to S-7-12 (up to 38 males were attracted to one trap over a period of three days at Roccarossa). When we had only R-7-12 and the mixture of R-7-12 and S-7-12, some specimens were also in traps containing the mixture. Furthermore, in Monte Pollino (2010) and Loiano (2011) where *A. mannii* was abundant and where we placed only one trap baited with R-7-12, we found one and five males respectively in the traps (Table 3).

Figure 4. Sticky trap baited with R-7-12 with two males of *Jordanita notata*, Roccarossa, 15.vi.2010.

Table 1. Males of *Jordanita notata* attracted.

		Roccarossa	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
12.vi / 13.vi.2010	1	0	–
13.vi / 15.vi.2010	2	0	–
		Sperone	
Traps placed / control	–	R-7-12:S-7-12 (1:0.5)	R-7-12:S-7-12 (1:1)
09.vi / 17.vi.2010	–	3	0
		Sperone	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
18.vi / 18.vi.2010	0	1	–
		Roccarossa	
Traps placed / control	R-7-12	S-7-12	R-7-12:S-7-12 (1:1)
30.vi / 03.vii.2011	0	0	0
		Roccarossa	
Traps placed / control	R-7-12	–	R-7-12:S-7-12 (1:1)
03.vii / 04.vii.2011	1	–	0
		Capistrello (1)	
Traps placed / control	R-7-12	–	R-7-12:S-7-12 (1:1)
06.vii / 07.vii.2011	1	–	0

Table 2. Males of *Adscita geryon* attracted.

		Rocca di Mezzo	
Traps placed / control	R-7-12	S-7-12	–
09.vi / 09.vi.2010	0	1	–
		Sperone	
Traps placed / control	–	R-7-12:S-7-12 (1:0.5)	R-7-12:S-7-12 (1:1)
09.vi / 17.vi.2010	–	1	0
		Sperone	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
18.vi / 18.vi.2010	0	2	–

Table 3. Males of *Adscita mannii* attracted.

		Roccarossa	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	S-7-12
30.vi / 03.vii.2011	0	0	38
		Lagonegro	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	S-7-12
04.vii / 04.vii.2011	0	0	1
		Castiglione Messer Marino	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	S-7-12
05.vii / 06.vii.2011	0	1	3
		Capistrello (2)	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	S-7-12
06.vii / 07.vii.2011	0	0	1

		Roccarossa	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
12.vi / 12.vi.2010	1	9	–
12.vi / 13.vi.2010	0	1	–
13.vi / 15.vi.2010	0	4	–
		Monte Pollino	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
13.vi / 13.vi.2010	0	15	–
13.vi / 14.vi.2010	0	3	–
		Lenola	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
11.vi / 16.vi.2010	1	0	–
		Sperone	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:0.5)	–
18.vi / 18.vi.2010	0	4	–
		Lago Ampollino	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	–
15.vi / 15.vi.2010	0	2	–
		Roccarossa	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	–
03.vii / 05.vii.2011	0	1	–
		Lago Ampollino	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	–
30.vi / 01.vii.2011	0	1	–
		Capistrello (1)	
Traps placed / control	R-7-12	R-7-12:S-7-12 (1:1)	–
06.vii / 07.vii.2011	0	3	–
		Monte Faito	
Traps placed / control	–	R-7-12	S-7-12
11.vi / 11.vi.2010	–	0	4
		Sperone	
Traps placed / control	–	R-7-12:S-7-12 (1:0.5)	R-7-12:S-7-12 (1:1)
09.vi / 09.vi.2010	–	1	1
09.vi / 17.vi.2010	–	3	1
		Monte Pollino	
Trap placed / control	R-7-12	–	–
15.vi / 15.vi.2010	1	–	–
		Loiano	
Trap placed / control	R-7-12	–	–
28.vi / 08.vii.2011	5	–	–
		Rocca di Mezzo	
Trap placed / control	–	R-7-12:S-7-12 (1:0.5)	–
17.vi / 17.vi.2010	–	1	–
		Lenola	
Trap placed / control	–	R-7-12:S-7-12 (1:1)	–
16.vi / 16.vi.2010	–	5	–
		Roccarossa	
Trap placed / control	–	–	S-7-12
12.vi / 12.vi.2010	–	–	1
		Monte Bondone	
Trap placed / control	–	–	S-7-12
09.vii / 09.vii.2011	–	–	12

Figure 5. Sticky trap baited with S-7-12 with 38 males of *Adscita mannii*, Roccarossa, 3.vii.2011.

Discussion

A. mannii is distributed from north-eastern Spain and south-western France through the southern parts of central Europe, Italy (including Sicily) and the Balkans to eastern Romania, Greek islands (except Crete), and north-western Turkey. *A. geryon* is known from the Iberian Peninsula and Great Britain (England, Wales) through most of central and southern Europe to Moldavia, south of European Russia and north-western Turkey. *J. notata* is distributed in western and central Europe, northern Mediterranean (including Sicily and Crete) to Ukraine, Crimea, Northern Caucasus, Transcaucasia, Turkey, and north-western Iran (Efetov and Tarmann 1999; Efetov 2004). The distributions of these three species in Italy are shown in Figs 1–3 (blue dots).

Our results confirm the data obtained earlier in Bulgaria and the Crimea that R-7-12 is an attractant for *Jordanita notata*, while S-7-12 attracts *Adscita geryon* and *A. mannii* (Subchev et al. 2010). It is interesting to note that the presence of S-7-12 does not inhibit the attractiveness of R-7-12 for *J. notata* and the presence of R-7-12 also does not influence the attractiveness of S-7-12 for *A. geryon* and *A. mannii*. In July 2007, during an expedition to Armenia, K. A. Efetov and V. M. Kiselev obtained the opposite result with *Zygaenoprocris taftana* (Alberti, 1939) (Efetov et al. 2011), a species from the subgenus *Molletia* Efetov, 2001, which was attracted to R-7-12, while

the presence of S-7-12 completely cancelled the attractiveness of R-7-12. This means that S-7-12 is an inhibitor of R-7-12 for *Z. taftana*. The genus *Zygaenoprocris* is represented by four subgenera (Efetov 2001a; 2001b). It looks as though the same situation as found in *Molletia* is present in two species of another subgenus, viz. *Zygaenoprocris* Hampson, 1900. During an expedition to Afghanistan in July 2011 A. Hofmann attracted *Zygaenoprocris* (*Zygaenoprocris*) *eberti* (Alberti, 1968) and *Z.* (*Z.*) *chalcochlora* Hampson, 1900, to R-7-12 and a mixture of R-7-12+R-9-14 (Subchev 2014; Efetov, Hofmann and Tarmann 2014).

Jordanita notata belongs to the subgenus *Tremewania* Efetov & Tarmann, 1999, *Adscita geryon* to the subgenus *Adscita* Retzius, 1783, and *A. mannii* to the subgenus *Tarmannita* Efetov, 2000 (Efetov and Tarmann 1999; Efetov 2004). Additional investigations are necessary to find attractants for representatives of the three other subgenera of Procridinae that inhabit Italy, viz. *Roccia* Alberti, 1954 (one species), *Jordanita* Verity, 1946 (three species), and *Solaniterna* Efetov, 2004 (one species).

It seems that the same attractants can be active for different species of the subgenus, but the attractiveness for different species can depend on the ratio of the components in the mixture. For example, the subgenus *Primilliberis* Alberti, 1954, of the genus *Illiberis* Walker, 1854, includes four species (Efetov 1997; Efetov and Tarmann 2012), and in two of them, viz. *I.* (*P.*) *rotundata* and *I.* (*P.*) *pruni*, the males were attracted by different ratios of R-7-12 and R-9-14 (Subchev et al. 2012; 2013). It is possible that a similar situation can be present in *Adscita* (*Adscita*), *Adscita* (*Tarmannita*) and *Jordanita* (*Tremewania*). The confirmation of this needs further investigations.

Acknowledgements

We thank our friend Dr W. G. Tremewan (Great Britain) for his company and help during our field trips in Italy in 2010 and 2011 and for editing the English text. This research was partially supported by a Grant DO02-244/2008 from the Bulgarian National Scientific Fund.

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